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(54) Title: AZEOTROPE-LIKE COMPOSITIONS OF 1,1,1,3,3-PENTAFLUOROBUTANE

(57) Abstract

Disclosed are binary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane (HFC-365mfc) and 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-10mee) or nonafluoromethoxybutane. The present invention further includes ternary or quaternary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane and 1,1,1,2,3,4,4,5,5-decafluoropentane or nonafluoromethoxybutane, and additionally trans-1,2-dichloroethylene, n-propyl bromide, acetone, methanol, ethanol or isopropanol.

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TITLE

AZEOTROPE-LIKE COMPOSITIONS OF 1,1,1,3,3-PENTAFLUOROBUTANE

FIELD OF THE INVENTION

The present invention relates to binary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane and 1,1,1,2,3,4,4,5,5,5-decafluoropentane or nonafluoromethoxybutane. The present invention further relates to ternary or quaternary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane and 1,1,1,2,3,4,4,5,5,5-decafluoropentane or nonafluoromethoxybutane, and additionally at least one of trans-1,2-dichloroethylene, n-propyl bromide , acetone, methanol, ethanol or isopropanol.

BACKGROUND

In recent years it has been pointed out that certain kinds of halogenated hydrocarbon compounds used in cleaning applications may adversely affect the stratospheric ozone layer when released into the atmosphere. Although this proposition has not yet been completely established, there is a movement toward the control of the use and the production of certain chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC)-based cleaning compositions under an international agreement. Accordingly, there is a demand for the development of new compositions that have a lower ozone depletion potential than conventional CFC and HCFC-based cleaning compositions, while still achieving acceptable utility in cleaning applications.

In refrigeration and cleaning apparatus, compositions may be lost during operation through leaks in shaft seals, hose connections, soldered joints and broken lines. In addition, the working composition may be released to the atmosphere during maintenance procedures on equipment. If the composition is not a pure component or an azeotropic or azeotrope-like composition, the composition may change when leaked or discharged to the atmosphere from the equipment, which may cause the composition remaining in the equipment to become flammable or to exhibit unacceptable performance. Accordingly, it is desirable to use as a refrigerant or cleaning composition a single fluorinated hydrocarbon or an azeotropic or azeotrope-like composition which fractionates to a negligible degree upon leak or boil off.

Hydrofluorocarbons (HFCs) have been proposed as replacements for CFCs and HCFCs in cleaning and drying compositions used by the electronics industry. However, many HFCs have limited solvency for electronics industry soils such as hydrocarbon or silicon oils and soldering flux residues. Accordingly, there is a need for HFC-based cleaning compositions which exhibit acceptable solubility for such electronics industry soils.

In applications where the potential of fire and fire's toxic byproducts are a concern, it is desirable for refrigerant and cleaning compositions to be nonflammable in both liquid and vapor phases, during operation and when charging fresh composition to a system or after composition has leaked from a system. Accordingly, it is preferred that compositions used to replace the conventional HCFC and CFC-based compositions are nonflammable.

It is also desireable that compositions offered to solve the aforementioned problems have a low global warming potential (GWP).

The electronics industry, and industries supporting those requiring cleaning solutions, as well as the refrigeration industry, continue to search for compositions that solve the aforementioned problems, and the following disclosures are evidence of such effort:

- Barthelemy et al. in US patent number 5,478,492 disclose azeotropic and azeotrope-like compositions of 1,1,1,3,3-pentafluorobutane, 1,2-dichloroethylene and optionally a C_1-C_3 alkanol.
- Michaud in US patent number 5,268,121 discloses azeotropic compositions of 1,1,1,3,3-pentafluorobutane and methanol.
- Pennetreau in US patent number 5,445,757 discloses azeotropic or pseudo-azeotropic compositions of 1,1,1,3,3-pentafluorobutane and ethanol.
- Michaud in US patent number 5,268,120 discloses azeotropic compositions of 1,1-dichloro-1-fluoroethane, 1,1,1,3,3-pentafluorobutane and methanol.
- Toshio in Japan unexamined patent publication Hei 5-168805 discloses a composition of 1,1,1,3,3-pentafluorobutane, a solvent and a fatty acid salt surfactant.

o Toshio in Japan unexamined patent publication Hei 5-302098 discloses a composition of at least one $R^1CH_2R^2$, wherein R^1 and R^2 may be HFC-radicals, a surfactant, and optionally an alcohol, ketone or hydrohalocarbon.

o Kiyoshi in Japan unexamined patent publication Hei 5-171185 discloses a composition of 1,1-dichloro-1-fluoroethane and 1,1,1,3,3-pentafluorobutane, and optionally containing alcohol.

o Toshio et al. in Japan unexamined patent publication Hei 5-171190 discloses a composition of 1,1,1,3,3-pentafluorobutane, a solvent and a nonionic surfactant.

o Barthelemy et al. in World Intellectual Property Organization international publication WO 9630487 disclose compositions containing a C_3-C_{10} hydrofluorocarbon, a cosolvent and a imidazoline surfactant.

o Flynn et al. in World Intellectual Property Organization international publication WO 9636689 disclose azeotropic and azeotrope-like compositions of hydrofluorocarbon ethers with a variety of organic solvents.

o Merchant in US patent number 5,196,137 discloses azeotropic compositions of 1,1,1,2,3,4,4,5,5,5-decafluoropentane and dichloroethylenes.

o Merchant in US patent number 5,064,560 discloses azeotropic compositions of 1,1,1,2,3,4,4,5,5,5-decafluoropentane, trans-1,2-dichloroethylene and an alcohol.

o DeGroot in World Intellectual Property Organization international publication WO 9902616 disclose azeotropic and azeotrope-like compositions of 1-bromopropane and 1,1,1,2,3,4,4,5,5,5-decafluoropentane optionally containing cosolvents.

o Michinori et al. in Japan unexamined patent publication Hei 10-36894 discloses a composition being a mixture of a hydrofluorocarbon and/or a hydrofluoroether and an organic compound which has boiling point of at least 50°C higher than the boiling point of said hydrofluorocarbon or hydrofluoroether.

o Henry in World Intellectual Property Organization international publication WO 9850517 discloses compositions of 1-bromopropane and a solvency adjusting agent which may be a hydrofluorocarbon.

For the foregoing reasons, there is a need in the electronics industry, and industries supporting those requiring cleaning solutions, as well as the refrigeration industry, for compositions that solve the aforementioned problems.

SUMMARY

The compositions of the present invention solve the aforementioned multiple problems confronting the cleaning and refrigeration industries. The present compositions are: non-ozone depleting; low GWP; essentially non-fractioning azeotrope-like compositions; non-flammable; superior in refrigeration performance; and superior in cleaning performance and solubility for conventional-electronics industry soils (oils and fluxes). The present invention includes binary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane and 1,1,1,2,3,4,4,5,5,5-decafluoropentane or nonafluoromethoxybutane. The present invention further includes ternary or quaternary azeotrope-like compositions consisting essentially of 1,1,1,3,3-pentafluorobutane and 1,1,1,2,3,4,4,5,5,5-decafluoropentane or nonafluoromethoxybutane, and additionally trans-1,2-dichloroethylene (tDCE), n-propyl bromide (nPB), acetone, methanol, ethanol or isopropanol.

DETAILED DESCRIPTION

The azeotrope-like compositions of the present invention include 1,1,1,3,3-pentafluorobutane, and are selected from the group consisting of:

(i) compositions consisting essentially of 1-99 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane and 1-99 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 58.6 kPa to 100.9 kPa at a temperature of 40°C;

(ii) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent methanol, wherein said composition has a vapor pressure of from 72.9 kPa to 112.2 kPa at a temperature of 40°C;

(iii) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-

pentafluorobutane and 1-15 weight percent ethanol, wherein said composition has a vapor pressure of from 72.2 kPa to 105.5 kPa at a temperature of 40°C;

(iv) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent isopropanol, wherein said composition has a vapor pressure of from 61.8 kPa to 103.2 kPa at a temperature of 40°C;

(v) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 28-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 73.8 kPa to 100.3 kPa at a temperature of 40°C;

(vi) compositions consisting essentially of 1-80 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-66 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 102.8 kPa to 118.8 kPa at a temperature of 40°C;

(vii) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 116.0 kPa to 128.2 kPa at a temperature of 40°C;

(viii) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 107.1 kPa to 118.5 kPa at a temperature of 40°C;

(ix) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-

10 weight percent isopropanol, wherein said composition has a vapor pressure of from 104.6 kPa to 114.9 kPa at a temperature of 40°C;

(x) compositions consisting essentially of 1-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 30-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-49 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 70.9 kPa to 106.5 kPa at a temperature of 40°C;

(xi) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 89.9 kPa to 117.0 kPa at a temperature of 40°C;

(xii) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 85.8 kPa to 108.3 kPa at a temperature of 40°C;

(xiii) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 78.7 kPa to 105.1 kPa at a temperature of 40°C;

(xiv) compositions consisting essentially of 1-67 and 92-99 weight percent nonafluoromethoxybutane and 33-99 and 1-8 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 50.1 kPa to 100.9 kPa at a temperature of 40°C;

(xv) compositions consisting essentially of 1-90 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent methanol, wherein said composition has a vapor pressure of from 77.9 kPa to 113.2 kPa at a temperature of 40°C;

(xvi) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 39-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 82.7 kPa to 105.3 kPa at a temperature of 40°C;

(xvii) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 39-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 82.1 kPa to 103.1 kPa at a temperature of 40°C;

(xviii) compositions consisting essentially of 1-98 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-98 weight percent acetone, wherein said composition has a vapor pressure of from 52.1 kPa to 100.3 kPa at a temperature of 40°C;

(xix) compositions consisting essentially of 1-75 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-64 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 93.4 kPa to 118.7 kPa at a temperature of 40°C;

(xx) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 113.1 kPa to 127.8 kPa at a temperature of 40°C;

(xxi) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 104.9 kPa to 113.8 kPa at a temperature of 40°C;

(xxii) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-

pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-9 weight percent isopropanol, wherein said composition has a vapor pressure of from 103.8 kPa to 111.1 kPa at a temperature of 40°C;

(xxiii) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 30-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-49 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 90.7 kPa to 106.6 kPa at a temperature of 40°C; and

(xxiv) compositions consisting essentially of 1-70 weight percent nonafluoromethoxybutane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 93.4 kPa to 118.0 kPa at a temperature of 40°C, and

wherein after 50 weight percent of said composition is evaporated or boiled off, the vapor pressure of the composition remaining has changed from the vapor pressure of said composition before evaporation or boil-off by 10 percent or less.

Preferrably, the azeotrope-like compositions of the present invention are selected from the group consisting of:

(i) compositions consisting essentially of 10-90 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane and 10-90 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 65.9 kPa to 98.9 kPa at a temperature of 40°C;

(ii) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 100.1 kPa to 110.4 kPa at a temperature of 40°C;

(iii) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 96.9 kPa to 103.8 kPa at a temperature of 40°C;

(iv) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 92.5 kPa to 101.1 kPa at a temperature of 40°C;

(v) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 85.6 kPa to 95.1 kPa at a temperature of 40°C;

(vi) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-45 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 114.2 kPa to 118.0 kPa at a temperature of 40°C;

(vii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 116.0 kPa to 128.2 kPa at a temperature of 40°C;

(viii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 114.1 kPa to 119.3 kPa at a temperature of 40°C;

(ix) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 109.1 kPa to 116.7 kPa at a temperature of 40°C;

(x) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 30-70 weight percent 1,1,1,3,3-

pentafluorobutane and 10-40 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 91.1 kPa to 106.3 kPa at a temperature of 40°C;

(xi) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 98.8 kPa to 110.8 kPa at a temperature of 40°C;

(xii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 93.8 kPa to 103.3 kPa at a temperature of 40°C;

(xiii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 89.6 kPa to 99.1 kPa at a temperature of 40°C;

(xiv) compositions consisting essentially of 20-60 weight percent nonafluoromethoxybutane and 40-80 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 82.7 kPa to 96.9 kPa at a temperature of 40°C;

(xv) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 107.0 kPa to 113.2 kPa at a temperature of 40°C;

(xvi) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 48-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 92.0 kPa to 102.2 kPa at a temperature of 40°C;

(xvii) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 48-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 90.7 kPa to 100.5 kPa at a temperature of 40°C;

(xviii) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 40-80 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 88.0 kPa to 96.3 kPa at a temperature of 40°C;

(xix) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 30-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-40 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 104.9 kPa to 116.3 kPa at a temperature of 40°C;

(xx) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane,15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 121.1 kPa to 127.8 kPa at a temperature of 40°C;

(xxi) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane,12-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 104.9 kPa to 114.8 kPa at a temperature of 40°C;

(xxii) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 103.8 kPa to 113.6 kPa at a temperature of 40°C;

(xxiii) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 30-70 weight percent 1,1,1,3,3-

pentafluorobutane and 10-40 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 90.7 kPa to 106.6 kPa at a temperature of 40°C; and

(xxiv) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 101.8 kPa to 113.2 kPa at a temperature of 40°C, and

wherein after 50 weight percent of said composition is evaporated or boiled off, the vapor pressure of the composition remaining has changed from the vapor pressure of said composition before evaporation or boil-off by 10 percent or less.

As previously indicated, in refrigeration and cleaning apparatus, compositions may be lost during operation through leaks in shaft seals, hose connections, soldered joints and broken lines. In addition, the working composition may be released to the atmosphere during maintenance procedures on equipment. If the composition is not a pure component or an azeotropic or azeotrope-like composition, the composition may change when leaked or discharged to the atmosphere from the equipment, which may cause the composition remaining in the equipment to become flammable or to exhibit unacceptable performance. Accordingly, it is desirable to use as a refrigerant or cleaning composition a single fluorinated hydrocarbon or an azeotropic or azeotrope-like composition, such as the present invention, that fractionates to a negligible degree upon leak or boil off.

By azeotrope-like composition is meant a constant boiling, or substantially constant boiling, liquid admixture of two or more substances that behaves as a single substance. One way to characterize an azeotrope-like composition is that the vapor produced by partial evaporation or distillation of the liquid has substantially the same composition as the liquid from which it was evaporated or distilled, that is, the admixture distills/refluxes without substantial composition change. Another way to characterize an azeotrope-like composition is that the bubble point vapor pressure and the dew point vapor pressure of the composition at a particular temperature are substantially the same. Herein, a composition is azeotrope-like if, after 50 weight percent of the composition is removed such as

by evaporation or boiling off, the difference in vapor pressure between the original composition and the composition remaining after 50 weight percent of the original composition has been removed by evaporation of boil off is less than 10 percent.

Herein, 1,1,1,3,3-pentafluorobutane may be referred to as HFC-365mfc, 1,1,1,2,3,4,4,5,5,5-decafluoropentane may be referred to as HFC-43-10mee, trans-1,2-dichloroethylene may be referred to as tDCE, and n-propylbromide may be referred to as nPB.

Nonafluoromethoxybutane ($C_4F_9OCH_3$) isomers of the present invention include 1,1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)propane ($CH_3OC(CF_3)_3$), 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane ($CH_3OCF_2CF_2CF_2CF_3$), 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxypropane ($CH_3OCF_2CF(CF_3)_2$), and 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxybutane ($CH_3OCF(CF_3)CF_2CF_3$) with approximate isomer boiling points of 60°C. Other components of the compositions of the present invention include the following: HFC-43-10mee, normal boiling point 54°C; HFC-365mfc, normal boiling point 40°C; methanol, normal boiling point 65°C; ethanol, normal boiling point 78°C; isopropanol, normal boiling point 82°C; n-propylbromide, normal boiling point 71°C; trans-1,2-dichloroethylene, normal boiling point 48°C; and acetone, normal boiling point 56°C.

The pure components forming the compositions of the present invention have the following vapor pressures at 40°C:

Component	Psia	kPa
HFC-365mfc	14.67	101.1
HFC-43-10mee	8.36	57.6
$C_4F_9OCH_3$	7.07	48.7
tDCE	11.27	77.7
nPB	4.18	28.8
Methanol	5.11	35.2
Ethanol	2.59	17.9
Isopropanol	2.00	13.8
Acetone	8.19	56.5

Substantially constant boiling, azeotrope-like compositions were surprisingly discovered by the present inventors and include the below compositions (in weight percent) at a temperature of 40°C (in the below table, HFC-43-10mee is further abbreviated as 43-10mee and HFC-365mfc is further abbreviated as 365mfc):

Composition	Azeotrope-like Range	Preferred Range
43-10mee/365mfc	1-99/1-99	10-90/10-90
43-10mee/365mfc/methanol	1-95/1-98/1-15	10-40/50-89/1-10
43-10mee/365mfc/ethanol	1-95/1-98/1-15	10-40/50-89/1-10
43-10mee/365mfc/isopropanol	1-95/1-98/1-15	10-40/50-89/1-10
43-10mee/365mfc/acetone	1-70/28-98/1-10	10-40/50-89/1-10
43-10mee/365mfc/tDCE	1-80/1-98/1-66	10-50/20-70/10-45
43-10mee/365mfc/tDCE/methanol	1-60/10-97/1-45/1-10	10-50/10-50/15-45/1-6
43-10mee/365mfc/tDCE/ethanol	1-60/10-97/1-45/1-10	10-50/10-50/15-45/1-6
43-10mee/365mfc/tDCE/isopropanol	1-60/10-97/1-45/1-10	10-50/10-50/15-45/1-6
43-10mee/365mfc/nPB	1-50/30-98/1-49	10-50/30-70/10-40
43-10mee/365mfc/nPB/methanol	1-70/10-97/1-35/1-10	10-50/20-70/12-35/1-6
43-10mee/365mfc/nPB/ethanol	1-70/10-97/1-35/1-10	10-50/20-70/12-35/1-6
43-10mee/365mfc/nPB/isopropanol	1-70/10-97/1-35/1-10	10-50/20-70/12-35/1-6
$C_4F_9OCH_3$/365mfc	1-67/33-99, 92-99/1-8	20-60/40-80
$C_4F_9OCH_3$/365mfc/methanol	1-90/1-98/1-15	10-40/50-89/1-10
$C_4F_9OCH_3$/365mfc/ethanol	1-60/39-98/1-10	10-40/48-89/1-6
$C_4F_9OCH_3$/365mfc/isopropanol	1-60/39-98/1-10	10-40/48-89/1-6
$C_4F_9OCH_3$/365mfc/acetone	1-98/1-98/1-98	10-40/40-80/1-10
$C_4F_9OCH_3$/365mfc/tDCE	1-75/1-98/1-64	10-50/30-70/10-40
$C_4F_9OCH_3$/365mfc/tDCE/methanol	1-60/20-97/1-50/1-10	10-50/20-70/15-45/1-6
$C_4F_9OCH_3$/365mfc/tDCE/ethanol	1-50/20-97/1-50/1-10	10-50/20-70/12-45/1-6
$C_4F_9OCH_3$/365mfc/tDCE/isoprop	1-50/20-97/1-50/1-9	10-50/20-70/12-45/1-6
$C_4F_9OCH_3$/365mfc/nPB	1-50/30-98/1-49	10-50/30-70/10-40
$C_4F_9OCH_3$/365mfc/nPB/methanol	1-70/10-97/1-35/1-10	10-50/20-70/12-35/1-6

By effective amount is meant the amount of each component of the inventive compositions which, when combined, results in the formation of an azeotrope-like composition. This definition includes the amounts of each component, which amounts may vary depending on the pressure applied to the composition so long as the azeotrope-like compositions continue to exist at the

different pressures, but with possible different boiling points. Therefore, effective amount includes the amounts, such as may be expressed in weight percentages, of each component of the compositions of the instant invention that form an azeotrope-like compositions at temperatures or pressures other than as described herein. Therefore, effective amount includes the amounts of each component of the compositions of the instant invention which form azeotrope-like compositions at temperatures or pressures other than as described herein.

The azeotrope-like compositions of the present invention can be prepared by any convenient method including mixing or combining the desired amounts. A preferred method is to weigh the desired component amounts and thereafter combine them in an appropriate container.

The present compositions have low global warming potential. HFC-43-10mee has a 100 year GWP of 1300, whereas, HFC-365mfc has a 100 year GWP of 840. Though HFC-365mfc is flammable, mixtures of HFC-43-10mee and HFC-365mfc may be nonflammable and have a lower overall global warming impact than compositions comprising HFC-43-10mee as the only HFC component.

The present inventors discovered that replacement of HFC-43-10mee or $C_4F_9OCH_3$ in the presence of trans-dichloroethylene, n-propyl bromide or acetone with HFC-365mfc in compositions of the present invention, lowers global warming contribution and unexpectedly improves oil solubility.

Other components, such as aliphatic hydrocarbons having a boiling point of about 0 to 100°C, hydrofluorocarbon alkanes having a boiling point of about 0 to 100°C, hydrofluoropropanes having a boiling point of between about 0 to 100°C, hydrocarbon esters having a boiling point between about 0 to 100°C, hydrochlorofluorocarbons having a boiling point between about 0 to 100°C, hydrofluorocarbons having a boiling point of about 0 to 100°C, hydrochlorocarbons having a boiling point between about 0 to 100°C, chlorocarbons and perfluorinated compounds, may be added in small amounts to the azeotropic or azeotrope-like compositions described above without substantially changing the properties thereof, including the constant boiling behavior, of the compositions.

Additives known in the cleaning and refrigeration fields such as lubricants, corrosion inhibitors, surfactants, stabilizers, anti-foam agents, dyes and other appropriate materials may be added to, and used in the presence of, the present compositions of the invention for a variety of purposes, provided that such additives do not have an adverse influence on the present compositions for their intended application or change the basic and novel characteristics of the present azeotrope-like compositions as claimed. For instance, fluoroalkyl phosphate surfactants such as those disclosed by Dishart in U.S. patent number 5,908,022 may be dissolved in the present compositions. The resultant composition may find utility in dewatering (displacement drying) processes carried out in the semiconductor industry during fabrication of integrated circuits.

Although the present specification is directed to use of the present azeotrope-like compositions as cleaning agents and compression refrigerants, the present compositions may also find utility as expansion agents for polyolefins and polyurethanes (polymer foam blowing agents), aerosol propellants, heat transfer media, gaseous dielectrics, power cycle working fluids, polymerization media, particulate removal fluids, carrier fluids and buffing abrasive agents.

EXAMPLES

Specific examples illustrating the invention are given below. Unless otherwise stated therein, all percentages are by weight. In the following examples, HFC-43-10mee may be further abbreviated as 43-10mee, and HFC-365mfc may be further abbreviated as 365mfc.

EXAMPLE 1; Impact of Vapor Leakage on Vapor Pressure

A vessel is charged with an initial composition at a temperature of 40°C, and the vapor pressure of the composition is measured. The composition is allowed to leak from the vessel, while the temperature is held constant at 40°C, until 50 weight percent of the initial composition is removed, at which time the vapor pressure of the composition remaining in the vessel is measured. The results are summarized in Table 1 below.

TABLE 1

Composition	0 Wt% Evaporated		50 wt% Evaporated		% Change
	Psia	kPa	Psia	kPa	
43-10mee/365mfc					
1/99	14.64	100.9	14.63	100.9	0.1%
10/90	14.34	98.9	14.24	98.2	0.7%
20/80	13.97	96.3	13.78	95.0	1.4%
30/70	13.57	93.6	13.27	91.5	2.2%
40/60	13.12	90.5	12.71	87.6	3.1%
50/50	12.60	86.9	12.09	83.4	4.0%
60/40	12.02	82.9	11.42	78.7	5.0%
70/30	11.34	78.2	10.68	73.6	5.8%
80/20	10.53	72.6	9.90	68.3	6.0%
90/10	9.56	65.9	9.11	62.8	4.7%
99/1	8.50	58.6	8.43	58.1	0.8%
43-10mee/365mfc/methanol					
20/75/5	16.01	110.4	15.77	108.7	1.5%
1/98/1	16.13	111.2	15.00	103.4	7.0%
10/89/1	15.81	109.0	14.64	100.9	7.4%
10/80/10	16.28	112.2	15.86	109.4	2.6%
30/69/1	14.99	103.4	13.71	94.5	8.5%
30/64/6	15.55	107.2	15.14	104.4	2.6%
40/59/1	14.52	100.1	13.16	90.7	9.4%
35/64/1	14.76	101.8	13.44	92.7	8.9%
45/54/1	14.26	98.3	12.86	88.7	9.8%
45/50/5	14.81	102.1	14.26	98.3	3.7%
60/35/5	13.88	95.7	13.21	91.1	4.8%
70/30/5	11.34	78.2	10.68	73.6	5.8%
80/15/5	12.27	84.6	11.69	80.6	4.7%
90/5/5	11.22	77.4	10.94	75.4	2.5%
95/3/2	10.66	73.5	9.74	67.2	8.6%
1/84/15	16.42	113.2	15.35	105.8	6.5%
84/1/15	10.57	72.9	9.93	68.5	6.1%
22/75/3	15.89	109.6	15.48	106.7	2.6%
43-10mee/365mfc/ethanol					
20/75/5	14.79	102.0	14.59	100.6	1.4%
22/75/3	14.78	101.9	14.62	100.8	1.1%

1/98/1	15.30	105.5	15.00	103.4	2.0%
10/89/1	15.05	103.8	14.63	100.9	2.8%
10/80/10	14.94	103.0	14.41	99.4	3.5%
30/69/1	14.23	98.1	13.64	94.0	4.1%
30/64/6	14.38	99.1	14.07	97.0	2.2%
40/59/1	14.06	96.9	13.03	89.8	7.3%
35/64/1	14.25	98.3	13.34	92.0	6.4%
45/54/1	13.86	95.6	12.68	87.4	8.5%
46/50/4	13.80	95.1	13.46	92.8	2.5%
60/35/5	13.04	89.9	12.61	86.9	3.3%
70/35/5	11.34	78.2	10.68	73.6	5.8%
80/15/5	11.75	81.0	11.39	78.5	3.1%
90/5/5	10.93	75.4	10.76	74.2	1.6%
95/3/2	10.75	74.1	10.42	71.8	3.1%
84/1/15	10.47	72.2	9.70	66.9	7.4%
43-10mee/365mfc/isopropanol					
20/75/5	14.26	98.3	13.95	96.2	2.2%
22/75/3	14.25	98.3	14.01	96.6	1.7%
1/98/1	14.97	103.2	14.88	102.6	0.6%
10/89/1	14.67	101.1	14.49	99.9	1.2%
10/80/10	14.45	99.6	13.92	96.0	3.7%
30/69/1	13.88	95.7	13.49	93.0	2.8%
30/64/6	13.76	94.9	13.27	91.5	3.6%
40/59/1	13.42	92.5	12.92	89.1	3.7%
34/64/1	13.65	94.1	13.22	91.1	3.2%
45/54/1	13.16	90.7	12.62	87.0	4.1%
45/50/5	13.06	90.0	12.47	86.0	4.5%
60/30/5	12.14	83.7	11.46	79.0	5.6%
70/30/5	11.34	78.2	10.68	73.6	5.8%
80/15/5	10.58	72.9	10.04	69.2	5.1%
90/5/5	9.59	66.1	9.35	64.5	2.5%
95/3/2	9.32	64.3	9.07	62.5	2.7%
84/1/15	8.97	61.8	8.63	59.5	3.8%
43-10mee/365mfc/acetone					
20/75/5	13.17	90.8	12.31	84.9	6.5%
20/79/1	13.80	95.1	13.46	92.8	2.5%

20/72/8	12.75	87.9	11.55	79.6	9.4%
30/65/5	12.60	86.9	11.50	79.3	8.7%
35/61/4	12.50	86.2	11.45	78.9	8.4%
40/57/3	12.42	85.6	11.46	79.0	7.7%
50/47/3	11.83	81.6	10.75	74.1	9.1%
1/98/1	14.54	100.3	14.50	100.0	0.3%
60/38/2	11.44	78.9	10.47	72.2	8.5%
70/28/2	10.71	73.8	9.73	67.1	9.2%
10/80/10	13.19	90.9	12.28	84.7	6.7%
43-10mee/365mfc/tDCE					
27/45/28	17.08	117.8	16.99	117.1	0.5%
47/1/52	16.18	111.6	15.82	109.1	2.2%
1/50/49	17.23	118.8	16.94	116.8	1.7%
1/83/16	17.04	117.5	16.69	115.1	2.1%
80/1/19	16.05	110.7	15.11	104.2	5.9%
45/1/54	16.16	111.4	15.64	107.8	3.2%
1/45/54	17.08	117.8	16.56	114.2	3.0%
1/33/66	16.55	114.1	14.99	103.4	9.4%
1/98/1	14.91	102.8	14.75	101.7	1.1%
35/33/32	16.94	116.8	16.90	116.5	0.2%
20/60/20	17.01	117.3	16.65	114.8	2.1%
10/40/50	17.05	117.6	16.73	115.4	1.9%
50/30/20	16.57	114.2	15.97	110.1	3.6%
60/10/30	16.46	113.5	16.39	113.0	0.4%
25/45/30	17.12	118.0	17.06	117.6	0.4%
43-10mee/365mfc/tDCE/methanol					
30/40/25/5	18.59	128.2	18.36	126.6	1.2%
1/97/1/1	16.38	112.9	15.14	104.4	7.6%
20/50/20/10	18.50	127.6	17.66	121.8	4.5%
50/30/15/5	17.82	122.9	16.55	114.1	7.1%
60/20/17/3	17.75	122.4	16.69	115.1	6.0%
49/10/40/1	17.51	120.7	16.98	117.1	3.0%
40/23/35/2	16.82	116.0	16.78	115.7	0.2%
30/50/14/6	18.14	125.1	17.19	118.5	5.2%
10/70/12/8	18.33	126.4	17.55	121.0	4.3%
20/33/45/2	18.40	126.9	17.94	123.7	2.5%

26/20/50/4	18.16	125.2	17.85	123.1	1.7%
43-10mee/365mfc/tDCE/ethanol					
30/40/25/5	17.19	118.5	16.97	117.0	1.3%
1/97/1/1	15.53	107.1	15.14	104.4	2.5%
20/50/20/10	16.93	116.7	16.09	110.9	5.0%
50/30/15/5	16.55	114.1	15.61	107.6	5.7%
60/20/17/3	16.68	115.0	15.95	110.0	4.4%
49/10/40/1	16.86	116.2	16.75	115.5	0.7%
40/23/35/2	17.17	118.4	17.14	118.2	0.2%
30/50/14/6	16.72	115.3	15.95	110.0	4.6%
10/70/12/8	16.77	115.6	16.03	110.5	4.4%
20/33/45/2	17.30	119.3	17.07	117.7	1.3%
26/20/50/4	16.96	116.9	16.28	112.2	4.0%
43-10mee/365mfc/tDCE/isopropanol					
30/40/25/5	16.62	114.6	16.22	111.8	2.4%
1/97/1/1	15.21	104.9	15.00	103.4	1.4%
20/50/20/10	16.31	112.5	15.39	106.1	5.6%
50/30/15/5	15.82	109.1	14.55	100.3	8.0%
60/20/17/3	15.99	110.2	14.90	102.7	6.8%
49/10/40/1	16.46	113.5	16.40	113.1	0.4%
40/23/35/2	16.67	114.9	16.58	114.3	0.5%
30/50/14/6	16.10	111.0	15.14	104.4	6.0%
10/70/12/8	16.26	112.1	15.49	106.8	4.7%
20/33/45/2	16.93	116.7	16.66	114.9	1.6%
26/20/50/4	16.43	113.3	15.71	108.3	4.4%
43-10mee/365mfc/nPB					
27/45/28	14.36	99.0	13.71	94.5	4.5%
1/50/49	15.24	105.1	13.74	94.7	9.8%
1/60/39	15.45	106.5	15.00	103.4	2.9%
1/98/1	14.88	102.6	14.73	101.6	1.0%
20/60/20	14.98	103.3	14.68	101.2	2.0%
60/10/30	11.45	78.9	10.71	73.8	6.5%
80/1/19	10.29	70.9	10.22	70.5	0.7%
35/33/32	13.64	94.0	12.68	87.4	7.0%
50/30/20	13.22	91.1	12.56	86.6	5.0%

20/70/10	15.05	103.8	14.76	101.8	1.9%
5/55/40	15.22	104.9	14.57	100.5	4.3%
40/40/20	13.90	95.8	13.33	91.9	4.1%
25/45/30	14.40	99.3	13.71	94.5	4.8%
10/70/20	15.42	106.3	15.25	105.1	1.1%
43-10mee/365mfc/nPB/methanol					
30/40/25/5	15.70	108.2	14.91	102.8	5.0%
1/97/1/1	16.33	112.6	15.13	104.3	7.3%
20/50/20/10	16.22	111.8	15.10	104.1	6.9%
50/30/15/5	14.81	102.1	14.14	97.5	4.5%
60/20/17/3	13.97	96.3	13.27	91.5	5.0%
70/10/15/5	13.04	89.9	12.56	86.6	3.7%
40/22/35/3	14.33	98.8	13.05	90.0	8.9%
30/50/14/6	16.07	110.8	15.54	107.1	3.3%
10/70/12/8	16.97	117.0	16.61	114.5	2.1%
43-10mee/365mfc/nPB/ethanol					
30/40/25/5	14.69	101.3	13.98	96.4	4.8%
1/97/1/1	15.50	106.9	15.12	104.2	2.5%
20/50/20/10	15.06	103.8	13.83	95.4	8.2%
50/30/15/5	13.94	96.1	13.43	92.6	3.7%
60/20/17/3	13.31	91.8	12.85	88.6	3.5%
70/10/15/5	12.45	85.8	12.11	83.5	2.7%
40/23/35/2	13.61	93.8	12.52	86.3	8.0%
30/50/14/6	14.98	103.3	14.52	100.1	3.1%
10/70/12/8	15.71	108.3	15.22	104.9	3.1%
43-10mee/365mfc/nPB/isopropanol					
30/40/25/5	14.10	97.2	13.17	90.8	6.6%
1/97/1/1	15.18	104.7	14.99	103.4	1.3%
20/50/20/10	14.49	99.9	13.24	91.3	8.6%
50/30/15/5	13.16	90.7	12.38	85.4	5.9%
60/20/17/3	12.49	86.1	11.84	81.6	5.2%
70/10/15/5	11.42	78.7	10.88	75.0	4.7%
40/23/35/2	13.00	89.6	11.75	81.0	9.6%
30/50/14/6	14.38	99.1	13.70	94.5	4.7%
10/70/12/8	15.25	105.1	14.69	101.3	3.7%

$C_4F_9OCH_3$/365mfc					
1/99	14.64	100.9	14.63	100.9	0.1%
10/90	14.38	99.1	14.3	98.6	0.6%
20/80	14.05	96.9	13.86	95.6	1.4%
30/70	13.66	94.2	13.32	91.8	2.5%
40/60	13.2	91.0	12.68	87.4	3.9%
50/50	12.66	87.3	11.91	82.1	5.9%
60/40	12	82.7	11.01	75.9	8.3%
67/33	11.45	78.9	10.31	71.1	10.0%
99/1	7.27	50.1	7.13	49.2	1.9%
92/8	8.52	58.7	7.67	52.9	10.0%
$C_4F_9OCH_3$/365mfc/methanol					
20/75/5	16.29	112.3	16.16	111.4	0.8%
22/75/3	16.20	111.7	15.87	109.4	2.0%
1/98/1	16.15	111.4	15.01	103.5	7.1%
10/89/1	15.97	110.1	14.66	101.1	8.2%
10/80/10	16.42	113.2	16.14	111.3	1.7%
30/68/2	15.86	109.4	14.72	101.5	7.2%
30/64/6	15.94	109.9	15.69	108.2	1.6%
40/58/2	15.52	107.0	14.10	97.2	9.1%
60/35/5	14.57	100.5	13.97	96.3	4.1%
80/15/5	13.00	89.6	12.34	85.1	5.1%
90/5/5	11.87	81.8	11.49	79.2	3.2%
84/1/15	11.30	77.9	11.11	76.6	1.7%
$C_4F_9OCH_3$/365mfc/ethanol					
20/75/5	14.41	99.4	13.80	95.1	4.2%
22/75/3	14.36	99.0	13.89	95.8	3.3%
1/98/1	15.27	105.3	15.00	103.4	1.8%
10/89/1	14.83	102.2	14.58	100.5	1.7%
10/80/10	14.73	101.6	13.81	95.2	6.2%
30/68/2	13.86	95.6	13.40	92.4	3.3%
30/64/6	13.79	95.1	12.70	87.6	7.9%
40/58/2	13.35	92.0	12.56	86.6	5.9%
50/48/2	12.70	87.6	11.64	80.3	8.3%
60/39/1	11.99	82.7	10.84	74.7	9.6%

$C_4F_9OCH_3$/365mfc/isopropanol					
20/75/5	14.07	97.0	13.48	92.9	4.2%
22/75/3	14.06	96.9	13.61	93.8	3.2%
1/98/1	14.96	103.1	14.87	102.5	0.6%
10/89/1	14.58	100.5	14.43	99.5	1.0%
10/80/10	14.34	98.9	13.53	93.3	5.6%
30/69/1	13.70	94.5	13.27	91.5	3.1%
30/64/6	13.46	92.8	12.45	85.8	7.5%
40/58/2	13.15	90.7	12.39	85.4	5.8%
50/48/2	12.53	86.4	11.51	79.4	8.1%
60/39/1	11.91	82.1	10.78	74.3	9.5%
$C_4F_9OCH_3$/365mfc/acetone					
20/75/5	13.59	93.7	13.34	92.0	1.8%
20/79/1	13.96	96.3	13.76	94.9	1.4%
20/70/10	13.14	90.6	12.80	88.3	2.6%
30/55/15	12.33	85.0	11.91	82.1	3.4%
40/40/20	11.53	79.5	11.12	76.7	3.6%
40/20/40	10.27	70.8	9.97	68.7	2.9%
20/40/40	10.86	74.9	10.28	70.9	5.3%
10/30/60	9.96	68.7	9.28	64.0	6.8%
30/10/60	9.60	66.2	9.20	63.4	4.2%
10/60/30	11.82	81.5	11.17	77.0	5.5%
30/60/10	12.76	88.0	12.37	85.3	3.1%
60/30/10	11.28	77.8	10.70	73.8	5.1%
60/10/30	10.04	69.2	9.91	68.3	1.3%
80/10/10	9.84	67.8	9.27	63.9	5.8%
10/80/10	13.46	92.8	13.18	90.9	2.1%
10/10/80	9.04	62.3	8.55	59.0	5.4%
98/1/1	7.55	52.1	7.29	50.3	3.4%
1/98/1	14.55	100.3	14.53	100.2	0.1%
1/1/98	8.28	57.1	8.21	56.6	0.8%
$C_4F_9OCH_3$/365mfc/tDCE					
27/45/28	16.70	115.1	16.44	113.4	1.6%
47/1/52	14.06	96.9	14.00	96.5	0.4%
1/50/49	17.22	118.7	16.92	116.7	1.7%

1/83/16	17.03	117.4	16.69	115.1	2.0%
70/1/29	13.78	95.0	13.17	90.8	4.4%
35/1/64	13.99	96.5	13.69	94.4	2.1%
1/45/54	17.06	117.6	16.54	114.0	3.0%
1/35/64	16.63	114.7	15.31	105.6	7.9%
1/98/1	14.91	102.8	14.75	101.7	1.1%
35/33/32	16.32	112.5	15.98	110.2	2.1%
20/60/20	16.80	115.8	16.40	113.1	2.4%
10/40/50	16.87	116.3	16.48	113.6	2.3%
50/30/20	15.64	107.8	14.64	100.9	6.4%
60/10/30	14.75	101.7	14.11	97.3	4.3%
45/45/10	15.22	104.9	13.76	94.9	9.6%
75/1/24	13.55	93.4	12.46	85.9	8.0%
25/45/30	16.77	115.6	16.55	114.1	1.3%
$C_4F_9OCH_3$/365mfc/tDCE/methanol					
30/40/25/5	18.53	127.8	18.29	126.1	1.3%
1/97/1/1	16.4	113.1	15.14	104.4	7.7%
20/50/20/10	18.52	127.7	17.88	123.3	3.5%
50/30/15/5	17.57	121.1	16.6	114.5	5.5%
60/20/17/3	17.28	119.1	16.13	111.2	6.7%
40/23/35/2	17.92	123.6	16.87	116.3	5.9%
30/50/14/6	18.15	125.1	17.44	120.2	3.9%
10/70/12/8	18.38	126.7	17.74	122.3	3.5%
20/33/45/2	18.36	126.6	17.57	121.1	4.3%
26/20/50/4	18.26	125.9	17.85	123.1	2.2%
$C_4F_9OCH_3$/365mfc/tDCE/ethanol					
30/40/25/5	16.26	112.1	15.28	105.4	6.0%
1/97/1/1	15.51	106.9	15.14	104.4	2.4%
20/50/21/9	16.38	112.9	14.93	102.9	8.9%
40/23/35/2	15.76	108.7	15.15	104.5	3.9%
50/20/27/3	15.21	104.9	14.11	97.3	7.2%
30/50/15/5	16.03	110.5	14.65	101.0	8.6%
10/70/12/8	16.51	113.8	15.45	106.5	6.4%
20/33/45/2	16.65	114.8	16.17	111.5	2.9%
26/20/50/4	15.73	108.5	14.83	102.2	5.7%

$C_4F_9OCH_3$/365mfc/tDCE/isopropanol					
30/40/25/5	15.98	110.2	14.99	103.4	6.2%
1/97/1/1	15.20	104.8	15.00	103.4	1.3%
20/50/21/9	15.99	110.2	14.62	100.8	8.6%
40/23/35/2	15.62	107.7	14.98	103.3	4.1%
50/20/27/3	15.05	103.8	13.93	96.0	7.4%
30/50/15/5	15.73	108.5	14.38	99.1	8.6%
10/70/12/8	16.11	111.1	15.10	104.1	6.3%
20/33/45/2	16.47	113.6	15.95	110.0	3.2%
26/20/50/4	15.52	107.0	14.55	100.3	6.3%
$C_4F_9OCH_3$/365mfc/nPB					
27/45/28	14.41	99.4	13.62	93.9	5.5%
1/50/49	15.24	105.1	13.74	94.7	9.8%
1/60/39	15.45	106.5	14.97	103.2	3.1%
1/98/1	14.89	102.7	14.73	101.6	1.1%
20/60/20	15.03	103.6	14.71	101.4	2.1%
40/50/10	14.17	97.7	13.51	93.1	4.7%
35/33/32	13.65	94.1	12.32	84.9	9.7%
50/40/10	13.56	93.5	12.65	87.2	6.7%
50/30/20	13.15	90.7	12.09	83.4	8.1%
25/45/30	14.46	99.7	13.63	94.0	5.7%
10/70/20	15.46	106.6	15.30	105.5	1.0%
$C_4F_9OCH_3$/365mfc/nPB/methanol					
30/40/25/5	16.07	110.8	15.38	106.0	4.3%
1/97/1/1	16.35	112.7	15.13	104.3	7.5%
20/50/20/10	16.49	113.7	15.66	108.0	5.0%
50/30/15/5	15.33	105.7	14.69	101.3	4.2%
60/20/17/3	14.54	100.3	13.57	93.6	6.7%
70/10/15/5	13.54	93.4	12.97	89.4	4.2%
40/21/35/4	14.76	101.8	13.33	91.9	9.7%
30/50/14/6	16.42	113.2	16.04	110.6	2.3%
10/70/12/8	17.11	118.0	16.86	116.2	1.5%

The results of this Example show that these compositions are azeotrope-like because when 50 wt.% of an original composition is removed, the vapor pressure of the remaining composition is within about 10% or less of the vapor

pressure of the original composition, at a temperature of 40°C. Also, in some cases the pressure of a given composition is higher than the vapor pressure of any of the pure components in the composition.

EXAMPLE 2: Distillation

A solution containing 30.0 wt% HFC-43-10mee and 70.0 wt% HFC-365mfc was prepared in a suitable container and mixed thoroughly. The solution was distilled in a five plate Oldershaw distillation column (7 cm diameter, 40 cm height) using a 10:1 reflux to take-off ratio. Head and pot temperatures were read directly to 1°C. The distillation was performed at a pressure of 760 mmHg. Distillate compositions were determined by gas chromatography. Results are summarized in Table 2.

TABLE 2

	Temp (C)	Wt% Distilled	Weight Percentages in Cut	
Cuts	Head	or Recovered	365mfc	43-10mee
1	40	18.2	89.1	10.9
2	40	27.3	88.2	11.8
3	40	36.3	87.0	13.0
4	40	45.5	85.0	15.0
5	40	54.7	81.6	18.4
Heel	–	91.5	18.5	81.5

Analysis of the above data indicates small differences in head temperatures and distillate compositions as the distillation progressed, indicating azeotrope-like behavior.

EXAMPLE 3: Distillation

A solution containing 26.7 wt% HFC-43-10mee, 44.7 wt% HFC-365mfc and 28.6 wt% tDCE was prepared in a suitable container and mixed thoroughly. The solution was distilled in a five plate Oldershaw distillation column (7 cm diameter, 40 cm height) using a 10:1 reflux to take-off ratio. Head and pot temperatures were read directly to 1C. The distillation was performed at a pressure of 757.53 mmHg. Distillate compositions were determined by gas chromatography. Results are summarized in Table 3.

TABLE 3

	Temp (C)	Wt% Distilled	Weight Percentages in Cut		
Cuts	Head	or Recovered	43-10mee	365mfc	tDCE
1	35	16.9	14.5	51.7	33.8
2	35	25.8	14.9	51.2	33.9
3	35	35.0	15.6	50.3	34.1
4	35	44.2	16.6	49.1	34.3
5	35	53.6	17.9	47.6	34.5
Heel	–	89.7	67.4	28.4	4.2

Analysis of the above data indicates small differences in head temperatures and distillate compositions as the distillation progressed, indicating azeotrope-like behavior.

EXAMPLE 4: Oil Solubility

Compositions of the present invention were tested for room temperature solubility in mineral oil. Solubility was measured by weighing and placing an amount of oil in a suitable container, then slowly adding a composition of the present invention until the oil is completely dissolved. Results are shown in Table 4 below.

TABLE 4

Composition	Wt%	% Solubility
365mfc	100%	<0.4
43-10mee/365mfc	50/50	<0.4
$C_4F_9OCH_3$/365mfc	50/50	<0.4
365mfc/tDCE	62/38	6.0
43-10mee/tDCE	62/38	1.9
43-10mee/365mfc/tDCE	31/31/38	4.4
$C_4F_9OCH_3$/tDCE	62/38	5.8
$C_4F_9OCH_3$/365mfc/tDCE	31/31/38	7.0
365mfc/nPB	62/38	5.1
43-10mee/nPB	62/38	1.8

43-10mee/365mfc/nPB	31/31/38	4.6
$C_4F_9OCH_3$/nPB	62/38	5.4
$C_4F_9OCH_3$/365mfc/nPB	31/31/38	8.7

Though HFC-365mfc has relatively low solubility in mineral oil, it improves mineral oil solubility when displacing HFC-43-10mee or $C_4F_9OCH_3$ in a cleaning composition containing tDCE or n-propyl bromide (nPB). There is a synergistic effect between 365mfc and tDCE and with 365mfc and nPB which improves oil solubility.

EXAMPLE 5: Oil Solubility

Solubility was measured by the method shown in Example 4 for pure compound and compositions of the present inventions. Results are given in Table 5 below.

TABLE 5

Composition (wt%)	Wt% Solubility in DC-200 Silicone Oil	Wt% Solubility in Tapmatic Cutting Fluid
43-10mee (100%)	Immiscible	Immiscible
$C_4F_9OCH_3$ (100%)	0.9	Immiscible
365mfc	Immiscible	Immiscible
43-10mee/tDCE 61%/39%	3.5	9.6
43-10mee/365mfc/tDCE 33%/28%/39%	17.0	18.6
43-10mee/nPB 80%/20%	0.6	1.7
43-10mee/365mfc/nPB 20%/60%/20%	0.7	19.8
43-10mee/acetone 97%/3%	Immiscible	Immiscible
43-10mee/365mfc/acetone 50%/47%/3%	0.6	0.5

$C_4F_9OCH_3$/tDCE 68%/32%	19.6	0.7
$C_4F_9OCH_3$/365mfc/tCDE 35%/33%/32%	27.1	25.1
$C_4F_9OCH_3$/nPB 80%/20%	11.6	0.6
$C_4F_9OCH_3$/365mfc/nPB 20%/60%/20%	12.0	25.7

Results show that addition of HFC-365mfc to the compositions above demonstrates an unexpected improvement in solubility even though 365mfc is immiscible with tapmatic cutting fluid and silicone DC-200 oil.

EXAMPLE 6: Cleaning Performance

A suitable container was filled with compositions of the present invention shown in Table 4 and heated to the boiling point. Stainless steel nuts and bolts coated with various residues were suspended in the container for 10 seconds, then removed and observed. Results in Table 6 show residues are essentially completely removed.

Composition #1 - 25% 43-10mee / 45% 365mfc / 30% tDCE

Composition #2 - 30% 43-10mee / 40% 365mfc / 25% tDCE / 5% Methanol

Composition #3 - 25% 43-10mee / 45% 365mfc / 30% nPB

Composition #4 - 30% 43-10mee / 40% 365mfc / 25% nPB / 5% Methanol

Composition #5 - 25% $C_4F_9OCH_3$/ 45% 365mfc / 30% tDCE

Composition #6 - 30% $C_4F_9OCH_3$ / 40% 365mfc / 25% tDCE / 5% Methanol

Composition #7 - 25% $C_4F_9OCH_3$ / 45% 365mfc / 30% nPB

TABLE 6

% REMOVED

Composition	Boiling Point (°C)	DC-200 SILICONEOIL	TAPAMATIC CUTTING FLUID	MIL-5606G
Composition #1	35	100%	100%	98%
Composition #2	34	100%	100%	98%
Composition #3	44	100%	100%	98%
Composition #4	40	100%	100%	98%
Composition #5	36	100%	100%	98%
Composition #6	34	100%	100%	98%
Composition #7	43	100%	100%	98%

EXAMPLE 7: Cleaning Performance

A suitable container was filled with compositions of the present invention shown in Table 7 and heated to the boiling point. Stainless steel nuts and bolts coated with various residues were suspended in the container for 10 seconds, then removed and observed. Oil solubility was also measured. Results in Table 7 show residues are essentially completely removed.

Composition #1 - 33% 43-10mee / 28% 365mfc / 39% tDCE

Composition #2 - 10% 43-10mee / 40% 365mfc / 50% tDCE

Composition #3 - 45% 43-10mee / 1% 365mfc / 54% tDCE

Composition #4- 20% 43-10mee / 60% 365mfc / 20% nPB

Composition #5- 60% 43-10mee / 10% 365mfc / 30% nPB

Composition #6- 40% 43-10mee / 40% 365mfc / 20% nPB

Composition #7 - 35% 43-10mee / 61% 365mfc / 4% Acetone

Composition #8 - 20% 43-10mee / 72% 365mfc / 8% Acetone

Composition #9 - 50% 43-10mee / 47% 365mfc / 3% Acetone

Composition #10 – 35% $C_4F_9OCH_3$ / 33% 365mfc / 32% tDCE

Composition #11 – 10% $C_4F_9OCH_3$ / 40% 365mfc / 50% tDCE

Composition #12 – 60% $C_4F_9OCH_3$ / 10% 365mfc / 30% tDCE

Composition #13 - 20% $C_4F_9OCH_3$/ 60% 365mfc / 20% nPB

Composition #14 - 50% $C_4F_9OCH_3$/ 30% 365mfc / 20% nPB

Composition #15 - 1% $C_4F_9OCH_3$/ 50% 365mfc / 49% nPB

Composition #16 - 20% $C_4F_9OCH_3$ / 70% 365mfc / 10% Acetone

Composition #17 - 10% $C_4F_9OCH_3$ / 60% 365mfc / 30% Acetone

Composition #18 - 30% $C_4F_9OCH_3$ / 10% 365mfc / 60% Acetone

Composition #19 - 30% $C_4F_9OCH_3$ / 50% 365mfc / 5% Methanol/15% nPB

TABLE 7

%Removed / Wt% Solubility

Composition	DC-200 SILICONEOIL	TAPAMATIC CUTTING FLUID	Krytox®	MIL-5606G
#1 - % Removed	100%	100%	100%	100%
% Solubility	16.0%	22.6%	4.4%	0.5%
#2 - % Removed	100%	100%	100%	100%
% Solubility	22.2%	41.5%	2.9%	21.2%
#3 - % Removed	100%	100%	100%	100%
% Solubility	15.5%	25.0%	1.3%	14.0%
#4 - % Removed	100%	100%	100%	100%
% Solubility	1.4%	12.6%	5.6%	0.4%
#5 - % Removed	100%	100%	100%	100%
% Solubility	1.0%	11.0%	17.7%	1.7%
#6 - % Removed	100%	100%	100%	100%
% Solubility	0.8%	2.7%	29.0%	0.5%
#7 - % Removed	90%	100%	100%	80%
% Solubility	1.5%	1.4%	14.0%	Immiscible
#8 - % Removed	60%	100%	100%	90%
% Solubility	1.1%	2.6%	1.9%	0.9%
#9 - % Removed	90%	100%	100%	80%
% Solubility	0.2%	1.0%	32.3%	Immiscible
#10 - % Removed	100%	100%	100%	100%
% Solubility	12.9%	25.2%	21.8%	0.2%
#11 - % Removed	100%	100%	100%	100%
% Solubility	17.9%	14.4%	2.0%	21.0%
#12 - % Removed	100%	100%	100%	100%
% Solubility	15.1%	1.6%	22.7%	0.3%
#13 - % Removed	100%	100%	100%	100%
% Solubility	12.7%	25.8%	4.6%	0.3%
#14 - % Removed	100%	100%	100%	100%
% Solubility	9.6%	19.4%	32.8%	0.4%

#15 - % Removed	100%	100%	100%	100%
% Solubility	20.5%	21.4%	Immiscible	9.7%
#16 - % Removed	90%	100%	100%	80%
% Solubility	1.4%	1.9%	19.6%	Immiscible
#17 - % Removed	90%	100%	100%	80%
% Solubility	0.6%	43.6%	Immiscible	0.3%
#18 - % Removed	95%	100%	100%	85%
% Solubility	23.1%	39.2%	Immiscible	0.4%
#19 - % Removed	100%	100%	100%	95%
% Solubility	8.4%	26.9%	6.9%	0.4%

Krytox® is a trademark of the DuPont Company

EXAMPLE 8: Defluxing

Several single sided circuit boards were coated with Alpha 611F RMA rosin flux, then activated by heating to 165°C for 2 minutes. The boards were defluxed by rinsing at room temperature with the compositions shown in Table 8. Results show significant residue removal using compositions of the present invention.

TABLE 8

Composition	% Flux Removal
30% 43-10mee / 40% 365mfc / 25% tDCE / 5% Methanol	99
30% 43-10mee / 40% 365mfc / 25% nPB / 5% Methanol	95
30% $C_4F_9OCH_3$ / 40% 365mfc / 25% tDCE / 5% Methanol	100
30% $C_4F_9OCH_3$ / 40% 365mfc / 25% tDCE / 5% Isopropanol	100

EXAMPLE 9: Flammability Testing

Compositions of the present invention were tested for flammability by tag open cup method per ASTM 1310. No tag open cup flash points were observed for the compositions in Table 9 below, for the temperature ranges shown.

TABLE 9

Composition	Weight Percent	Temp Range (C)
43-10mee/365mfc/tDCE	25/45/30	0-36
43-10mee/365mfc/tDCE/ethanol	30/40/25/5	0-36
43-10mee/365mfc/nPB	25/45/30	0-35
43-10mee/365mfc/tDCE/isopropanol	30/40/25/5	0-37
$C_4F_9OCH_3$/365mfc/tDCE	25/45/30	0-36
$C_4F_9OCH_3$/365mfc/nPB	25/45/30	0-44

EXAMPLE 10: Flammability Testing

Compositions of the present invention were tested for flammability by tag closed cup method per ASTM D-56-93. No tag closed cup flash points were observed inside the cup for the compositions in Table 10 below, for the temperature ranges shown.

TABLE 10

Composition	Weight Percent	Temp Range (C)
43-10mee/365mfc/ethanol	60/15/5	-10 to 38
43-10mee/365mfc/tDCE	33/28/39	-10 to 38
43-10mee/365mfc/tDCE	45/1/54	-10 to 38
43-10mee/365mfc/nPB	20/60/20	-10 to 38
43-10mee/365mfc/acetone	70/28/2	-10 to 38
$C_4F_9OCH_3$/365mfc/ethanol	60/35/5	-10 to 38
$C_4F_9OCH_3$/365mfc/isopropanol	48/50/2	-10 to 38
$C_4F_9OCH_3$/365mfc/tDCE	35/33/32	-10 to 38
$C_4F_9OCH_3$/365mfc/nPB	20/60/20	-10 to 38
$C_4F_9OCH_3$/365mfc/acetone	80/10/10	-10 to 38
43-10mee/365mfc/tDCE/methanol	40/23/35/2	-10 to 38
43-10mee/365mfc/nPB/methanol	60/20/17/3	-10 to 38
$C_4F_9OCH_3$/365mfc/nPB/isopropanol	60/20/17/3	-10 to 38
$C_4F_9OCH_3$/365mfc/nPB/methanol	50/30/15/5	-10 to 38

EXAMPLE 11: Global Warming

Replacing an amount of HFC-43-10mee in cleaning mixtures with HFC-365mfc reduces the global warming of the mixture as shown in Table 11. Pure

component global warming data are taken from Scientific Assessment of Ozone Depletion, 1998 by the World Meterological Organization Global Ozone Research and Monitoring Project (Report No. 44, Geneva, 1999). Mixture GWPs are based on a weighted sum of individual component GWPs.

TABLE 11

	100 Yr GWP
HFC-4310mee	1700
HFC-365mfc	910
HFC-4310mee/HFC-365mfc wt%	
90/10	1621
80/20	1542
60/40	1384
40/60	1226
20/80	1068
10/90	989

EXAMPLE 12: Refrigerant Performance

Table 12 below shows the performance of compositions of the present invention as refrigerants. The data are based on the following conditions:

Evaporator Temperature	40.0F (4.4C)
Condenser Temperature	110.0F (43.3C)
Subcooled	10.0F (5.6C)
Return Gas Temperature	75.0F (23.9C)
Compressor Efficiency	70%

The refrigeration capacity is based on a compressor with a fixed displacement of 3.5 cubic feet per minute and 70% volumetric efficiency. Capacity is intended to mean the change in enthalpy of the refrigerant in the evaporator per pound of refrigerant circulated. i.e. the heat removed by the refrigerant in the evaporator per time. Coefficient of Performance (COP) is intended to mean the ratio of capacity to compressor work. It is a measure of refrigerant energy efficiency.

TABLE 12

Comp Wt%	Evap Psia	Cond Psia	Comp. Disch F	Glide Cond/Evap	COP	Cap (Btu/min)
CFC-113	2.7	12.8	156.3	0/0	4.18	14.8
43-10mee/365mfc						
5/95	3.6	16.1	145.9	0.1/0.2	4.09	21.1
30/70	3.3	15.3	142.9	1.1/1.5	4.07	19.6
95/5	2.1	10.9	133.7	1.1/1.3	3.96	13.0
$C_4F_9OCH_3$/365mfc						
5/95	3.5	16.0	145.8	0.5/0.7	4.10	20.9
30/70	3.0	14.3	142.9	3.2/3.8	4.08	18.3
95/5	1.6	8.8	132.2	1.9/2.1	3.97	10.3

Results of this example show addition of 365mfc to 43-10mee or $C_4F_9OCH_3$ significantly improves capacity while providing lower compressor discharge temperatures and comparable pressures to CFC-113. Fractionation or glide in the condenser and evaporator also demonstrate azeotrope-like behavior.

WHAT IS CLAIMED IS:

1. An azeotrope-like 1,1,1,3,3-pentafluorobutane-containing composition, wherein said composition is selected from the group consisting of:

(i) compositions consisting essentially of 1-99 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane and 1-99 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 58.6 kPa to 100.9 kPa at a temperature of 40°C;

(ii) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent methanol, wherein said composition has a vapor pressure of from 72.9 kPa to 112.2 kPa at a temperature of 40°C;

(iii) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent ethanol, wherein said composition has a vapor pressure of from 72.2 kPa to 105.5 kPa at a temperature of 40°C;

(iv) compositions consisting essentially of 1-95 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent isopropanol, wherein said composition has a vapor pressure of from 61.8 kPa to 103.2 kPa at a temperature of 40°C;

(v) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 28-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 73.8 kPa to 100.3 kPa at a temperature of 40°C;

(vi) compositions consisting essentially of 1-80 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-66 weight percent trans-1,2-dichloroethylene,

wherein said composition has a vapor pressure of from 102.8 kPa to 118.8 kPa at a temperature of 40°C;

(vii) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 116.0 kPa to 128.2 kPa at a temperature of 40°C;

(viii) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 107.1 kPa to 118.5 kPa at a temperature of 40°C;

(ix) compositions consisting essentially of 1-60 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-40 weight percent trans-1,2-dichloroethylene and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 104.6 kPa to 114.9 kPa at a temperature of 40°C;

(x) compositions consisting essentially of 1-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 30-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-49 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 70.9 kPa to 106.5 kPa at a temperature of 40°C;

(xi) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 89.9 kPa to 117.0 kPa at a temperature of 40°C;

(xii) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 85.8 kPa to 108.3 kPa at a temperature of 40°C;

(xiii) compositions consisting essentially of 1-70 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide, and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 78.7 kPa to 105.1 kPa at a temperature of 40°C;

(xiv) compositions consisting essentially of 1-67 and 92-99 weight percent nonafluoromethoxybutane and 33-99 and 1-8 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 50.1 kPa to 100.9 kPa at a temperature of 40°C;

(xv) compositions consisting essentially of 1-90 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-15 weight percent methanol, wherein said composition has a vapor pressure of from 77.9 kPa to 113.2 kPa at a temperature of 40°C;

(xvi) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 39-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 82.7 kPa to 105.3 kPa at a temperature of 40°C;

(xvii) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 39-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 82.1 kPa to 103.1 kPa at a temperature of 40°C;

(xviii) compositions consisting essentially of 1-98 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-98 weight percent acetone, wherein said composition has a vapor pressure of from 52.1 kPa to 100.3 kPa at a temperature of 40°C;

(xix) compositions consisting essentially of 1-75 weight percent nonafluoromethoxybutane, 1-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-64 weight percent trans-1,2-dichloroethylene,

wherein said composition has a vapor pressure of from 93.4 kPa to 118.7 kPa at a temperature of 40°C;

(xx) compositions consisting essentially of 1-60 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 113.1 kPa to 127.8 kPa at a temperature of 40°C;

(xxi) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 104.9 kPa to 113.8 kPa at a temperature of 40°C;

(xxii) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 20-97 weight percent 1,1,1,3,3-pentafluorobutane,1-35 weight percent trans-1,2-dichloroethylene and 1-9 weight percent isopropanol, wherein said composition has a vapor pressure of from 103.8 kPa to 111.1 kPa at a temperature of 40°C;

(xxiii) compositions consisting essentially of 1-50 weight percent nonafluoromethoxybutane, 30-98 weight percent 1,1,1,3,3-pentafluorobutane and 1-49 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 90.7 kPa to 106.6 kPa at a temperature of 40°C; and

(xxiv) compositions consisting essentially of 1-70 weight percent nonafluoromethoxybutane, 10-97 weight percent 1,1,1,3,3-pentafluorobutane, 1-35 weight percent n-propyl bromide and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 93.4 kPa to 118.0 kPa at a temperature of 40°C, and

wherein after 50 weight percent of said composition has evaporated or boiled off, the vapor pressure of the remaining composition has changed by 10 percent or less.

2. The azeotrope-like composition of Claim 1, said composition consisting essentially of:

(i) compositions consisting essentially of 10-90 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane and 10-90 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 65.9 kPa to 98.9 kPa at a temperature of 40°C;

(ii) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 100.1 kPa to 110.4 kPa at a temperature of 40°C;

(iii) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent ethanol, wherein said composition has a vapor pressure of from 96.9 kPa to 103.8 kPa at a temperature of 40°C;

(iv) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent isopropanol, wherein said composition has a vapor pressure of from 92.5 kPa to 101.1 kPa at a temperature of 40°C;

(v) compositions consisting essentially of 10-40 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 85.6 kPa to 95.1 kPa at a temperature of 40°C;

(vi) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-45 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 114.2 kPa to 118.0 kPa at a temperature of 40°C;

(vii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 116.0 kPa to 128.2 kPa at a temperature of 40°C;

(viii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 114.1 kPa to 119.3 kPa at a temperature of 40°C;

(ix) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 10-50 weight percent 1,1,1,3,3-pentafluorobutane, 15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 109.1 kPa to 116.7 kPa at a temperature of 40°C;

(x) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 30-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-40 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 91.1 kPa to 106.3 kPa at a temperature of 40°C;

(xi) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 98.8 kPa to 110.8 kPa at a temperature of 40°C;

(xii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 93.8 kPa to 103.3 kPa at a temperature of 40°C;

(xiii) compositions consisting essentially of 10-50 weight percent 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 20-70 weight percent 1,1,1,3,3-

pentafluorobutane, 12-35 weight percent n-propyl bromide, and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 89.6 kPa to 99.1 kPa at a temperature of 40°C;

(xiv) compositions consisting essentially of 20-60 weight percent nonafluoromethoxybutane and 40-80 weight percent 1,1,1,3,3-pentafluorobutane, wherein said composition has a vapor pressure of from 82.7 kPa to 96.9 kPa at a temperature of 40°C;

(xv) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 50-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent methanol, wherein said composition has a vapor pressure of from 107.0 kPa to 113.2 kPa at a temperature of 40°C;

(xvi) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 48-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 92.0 kPa to 102.2 kPa at a temperature of 40°C;

(xvii) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 48-89 weight percent 1,1,1,3,3-pentafluorobutane and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 90.7 kPa to 100.5 kPa at a temperature of 40°C;

(xviii) compositions consisting essentially of 10-40 weight percent nonafluoromethoxybutane, 40-80 weight percent 1,1,1,3,3-pentafluorobutane and 1-10 weight percent acetone, wherein said composition has a vapor pressure of from 88.0 kPa to 96.3 kPa at a temperature of 40°C;

(xix) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 30-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-40 weight percent trans-1,2-dichloroethylene, wherein said composition has a vapor pressure of from 104.9 kPa to 116.3 kPa at a temperature of 40°C;

(xx) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane,15-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 121.1 kPa to 127.8 kPa at a temperature of 40°C;

(xxi) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane,12-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent ethanol, wherein said composition has a vapor pressure of from 104.9 kPa to 114.8 kPa at a temperature of 40°C;

(xxii) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-45 weight percent trans-1,2-dichloroethylene and 1-6 weight percent isopropanol, wherein said composition has a vapor pressure of from 103.8 kPa to 113.6 kPa at a temperature of 40°C;

(xxiii) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 30-70 weight percent 1,1,1,3,3-pentafluorobutane and 10-40 weight percent n-propyl bromide, wherein said composition has a vapor pressure of from 90.7 kPa to 106.6 kPa at a temperature of 40°C; and

(xxiv) compositions consisting essentially of 10-50 weight percent nonafluoromethoxybutane, 20-70 weight percent 1,1,1,3,3-pentafluorobutane, 12-35 weight percent n-propyl bromide and 1-6 weight percent methanol, wherein said composition has a vapor pressure of from 101.8 kPa to 113.2 kPa at a temperature of 40°C, and

wherein after 50 weight percent of said composition has evaporated, the vapor pressure of the remaining composition has changed by 10 percent or less.

3. A process for cleaning a surface comprising:

a) contacting the surface with the composition of claims 1 or 2, and

b) recovering the cleaned surface from the composition.

4. A process for producing refrigeration, comprising condensing a composition of claims 1 or 2, and thereafter evaporating said composition in the vicinity of a body to be cooled.

5. A process for producing heat, comprising condensing a composition of Claim 1 or 2 in the vicinity of a body to be heated, and thereafter evaporating said composition..

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 00/07520

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C09K5/04 C11D7/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C09K C11D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C. [X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 July 2000	17/07/2000

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 00/07520

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Inte onal Application No
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